Highway Rehabilitation Integrating Pavement, Construction, and Traffic

CA4PRS Software V1.0

(*Construction Analysis for Pavement Rehabilitation Strategies*)

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CA4PRS Agenda

- CA4PRS Development
- CA4PRS Analysis Process
- CA4PRS Modeling
- CA4PRS Pilot Projects
- CA4PRS Outreach Efforts
- Discussion

CA4PRS Development

Why Was CA4PRS Developed?

- To quickly calculate construction productivity for Long-Life Pavement Rehabilitation Strategies (LLPRS) closures
- To identify the most important variables constraining productivity in extended closures (longer than 7-10 hr nighttime closures)
- To provide quantitative comparison of duration of alternative closure strategies for integration with planning, traffic, and pavement analyses

Integration Need for Long-life Pavement Rehabilitation

- Balance Conflicting Objectives: Long-life Design with Fast Construction and Minimum Traffic Delay
- Pavement Design
  - Structural sections to meet design life
  - Faster materials
  - Reduce thickness by increasing construction quality
- Construction Logistics
  - Fast-track construction, around the clock operations
  - Contracting and Project delivery: A+B+C+I/D+PF
  - Planning of Logistics, Resources, and Site Access
- Traffic Operations
  - Road user cost evaluation and congestion mitigation plan
  - Work-zone Information Systems and public outreach

CA4PRS Capability for LLPRS Projects

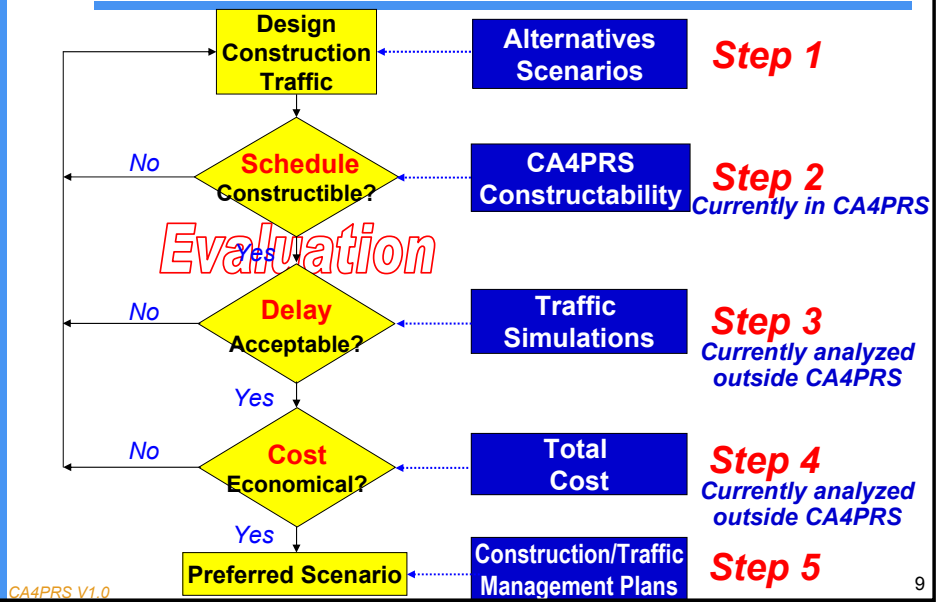
- Models Accelerated Rehabilitation Process
- Analyze a **maximum distance** of rehabilitation
- Estimate closure numbers and project duration
- Decision-making tool for LLPRS projects
  - Evaluate "What-if" rehabilitation strategies
  - Develop Plans: Design/Construction/Traffic
  - Check Construction Staging: Resident Engineer
  - Review Constructability of rehabilitation alternatives
- Establish Construction baseline for Integration of Pavement design, Construction logistics, and Traffic operations

Funding Supports for CA4PRS Software Development

- 1999-2001: Caltrans PPRC (DRI) for Modeling & Prototype Spreadsheet ($200,000)
- 2001-2002: FHWA Pooled-fund SPR-3(098) to code software ($200,000)
  - 4-State DOT(CA-MN-TX-WA) Pavement Technology Consortium (SPTC)
- 1999-2003: FHWA/ACPA/NAPA Funds for Case Studies ($130,000)
- 2001-2003: PPRC (DRI) Funding for Case Studies and Associated Traffic Studies ($200,000)
- 2002-2003: Fund for I-15 (D8) Implementation ($200,000)

CA4PRS Analysis Process

Selection Process for the Most Economic Rehabilitation Scenario



Step 1: CA4PRS V1.0 Main Inputs
Create Alternative Scenarios

- **Pavement Design**
  - Rehabilitation Strategy Alternatives
  - Design (Cross-section) Alternatives
  - Materials Alternatives
- **Traffic Control & Operations**
  - Construction Widows (Closure timing)
  - Lane Closure Alternatives
- **Construction Logistics and Constraints**
  - Activity Lead-lag relationships
  - Construction Resources Logistics
  - Weather Condition (AC Cooling time)

Step 2: CA4PRS Constructability
Schedule Analysis Outputs

- **CA4PRS Outputs**
  - Maximum Rehabilitation Production (lane-km)
  - Total Number of Construction Closures
  - Total Closure Durations
  - Parameters Sensitivity
- **Constructability Analysis**
  - Compares Mix, Base type, and Widened Truck lane
  - Evaluate Construction Schedule Benefits
- ***CA4PRS Outputs* => Inputs to Traffic Analysis**
  - CA4PRS 1.0 Run Traffic Analysis *Separately*
  - Demand-Capacity Model (HCM) Spreadsheet Developed
  - Version 2.0 will have the Embedded Traffic Module

Step 3: Traffic Delay Analysis
Road User Cost + Maximum Delay

- **Incorporated Traffic Analysis Tools**
  - Highway Capacity Manual (Spreadsheet)
  - Macro Simulation: FREQ
  - Microscopic Simulation: Paramics
- **Needed Additional Traffic Information**
  - Geometry: Nodes, Links, Lane numbers, Traffic Control
  - Demand: Hourly & Daily Counts, Truck percentage
  - Capacity: Construction Workzone Capacity
  - Traffic Demand Control: Reduction (No-show + Detours)
- **Traffic Analysis Outputs**
  - Total Road User Cost (RUC)
  - Maximum Delay per Closure
  - Demand Sensitivity

Step 4: Economic Analysis

Total Cost = Agency + Road User Costs

- **Comparison of Alternative Scenarios**
  - Select the Most Economical Rehabilitation Scenarios
- **Total Cost: Economic Analysis**
  - Total cost = RUC + Agency cost
  - Agency Cost = Construction + Traffic Handling
  - Apply a Discount Factor for Road User Cost
- **Other Qualitative Aspects**
  - Pavement Life Expectancy: LCCA
  - Environmental Aspects
  - Public Perception
  - Impact on Local Business

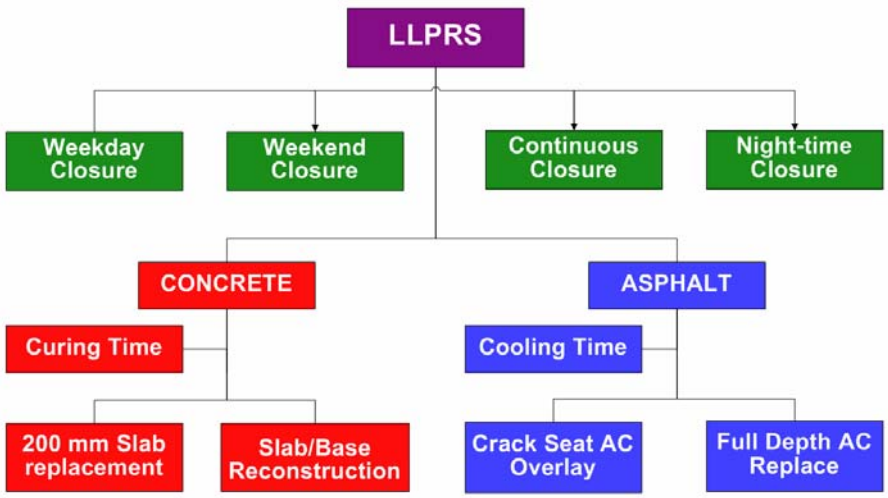
Step 5: Preferred Scenario

Construction & Traffic Management Plans

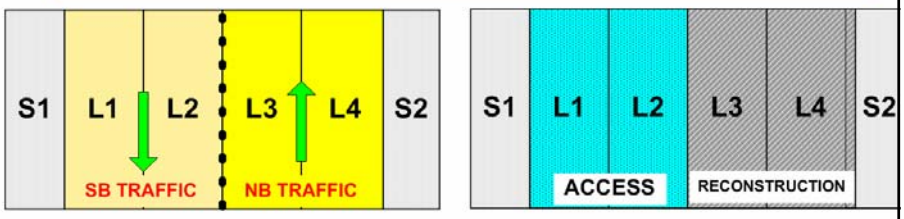
- **Construction Management Plan**
  - Rehabilitation Scope and Process
  - CPM Schedule
  - Contingency Plan
  - Incentives and “A + B” (Cost/Schedule) Contract
- **Traffic Management Plan**
  - (Automatic) Workzone Information Systems
  - Detour Plans
  - Public Outreach: Demand Reduction
  - Lane Closure Charts: Lane, Ramp, Connector
- **Implement Public Outreach**

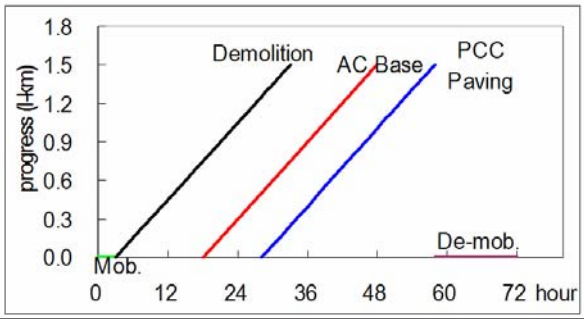
CA4PRS Modeling

CA4PRS Analysis Hierarchy

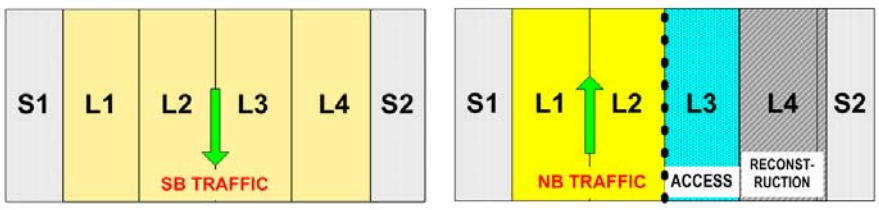


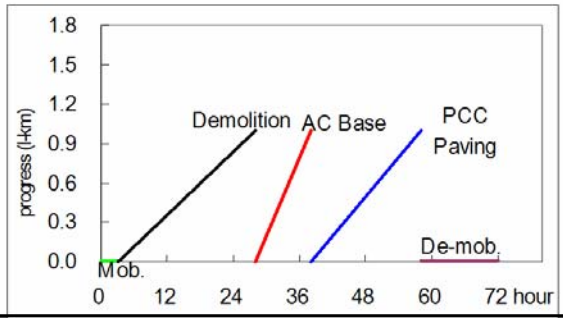
Full Closure (Counter-flow Traffic)
PCC Concurrent Double-lane Rehabilitation



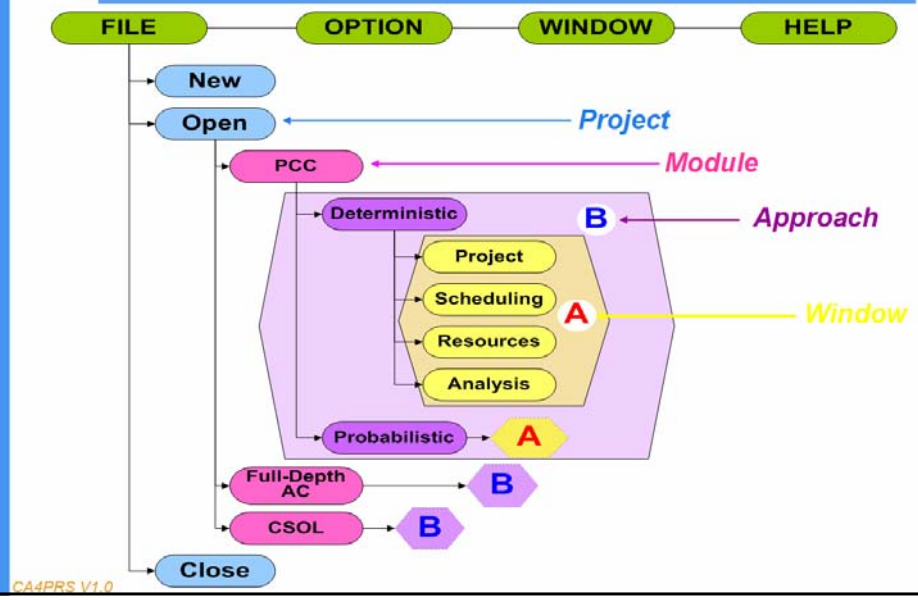


Half or Partial Closure
PCC Sequential Single-lane Rehabilitation



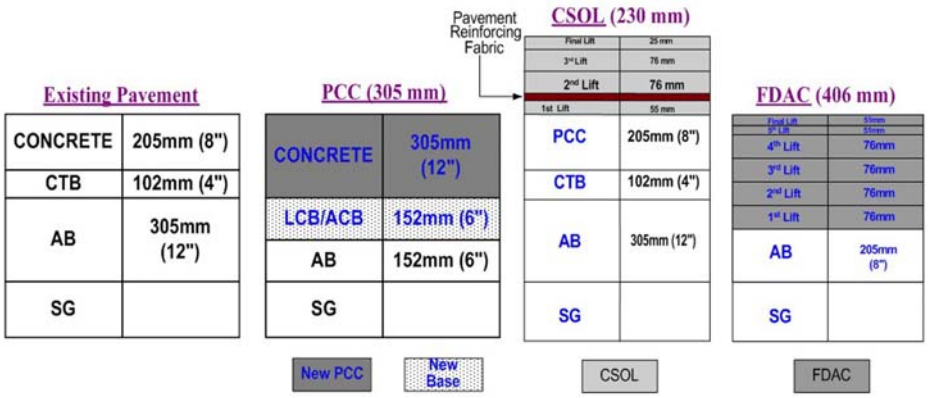


CA4PRS Software Menu Tree

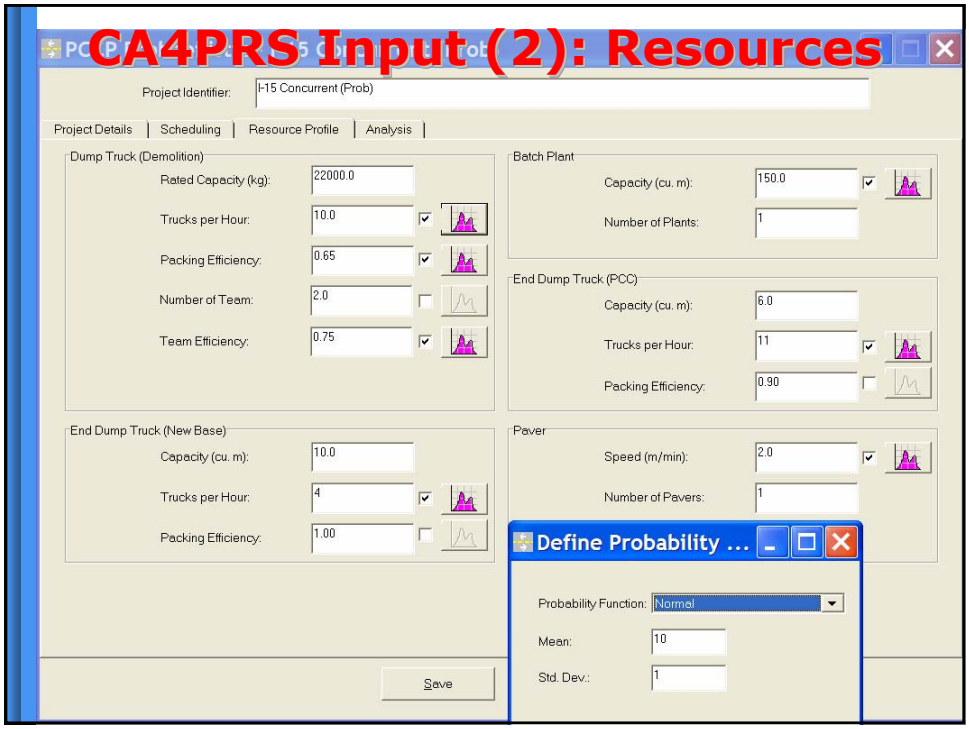


Major Caltrans Rehabilitation Strategies Modeled in CA4PRS

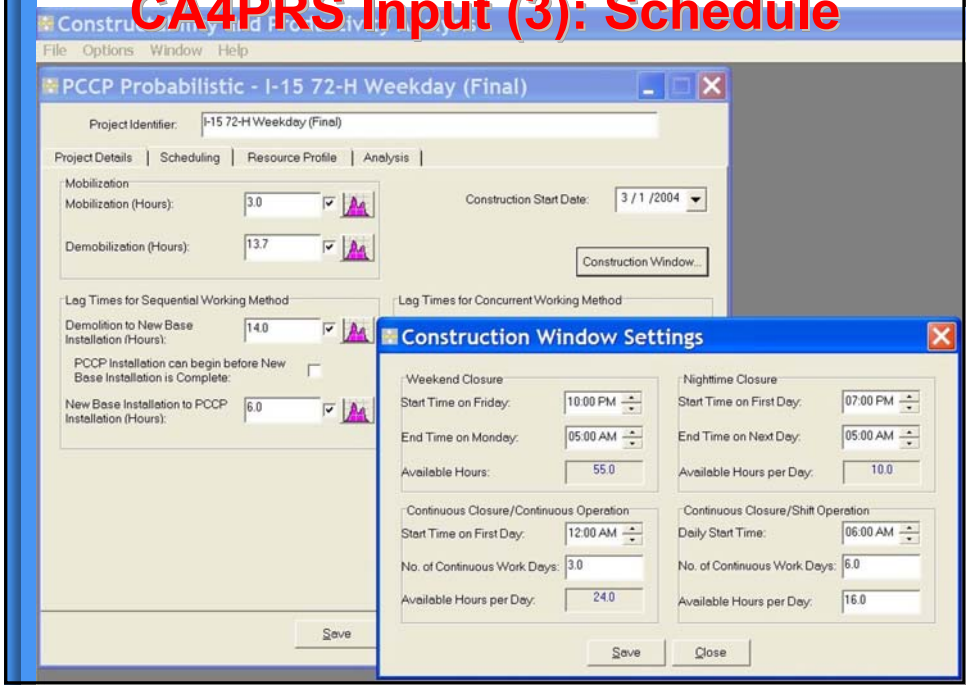
1. PCC (Concrete) Reconstruction
2. Crack-Seat AC Overlay
3. Full-depth AC Replacement



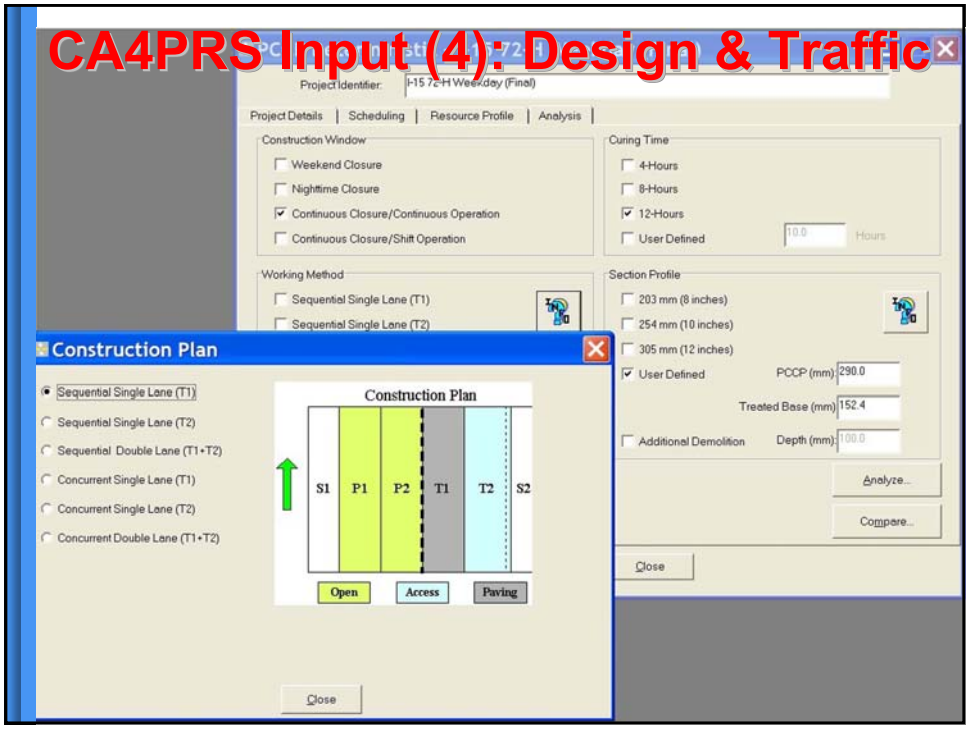
CA4PRS Input (2): Resources



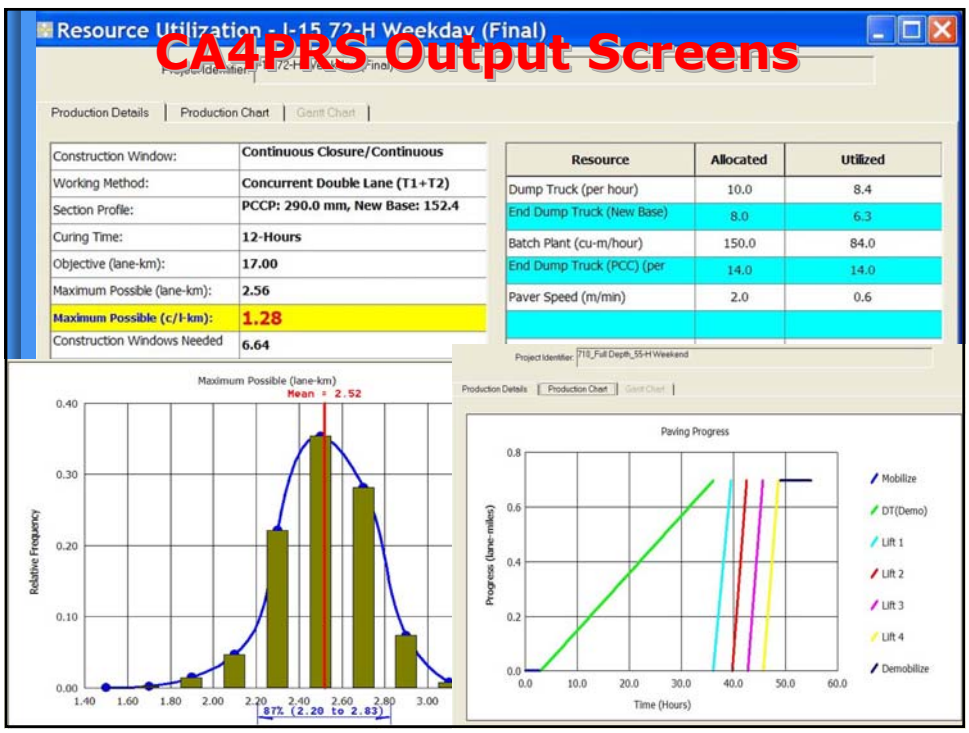
CA4PRS Input (3): Schedule

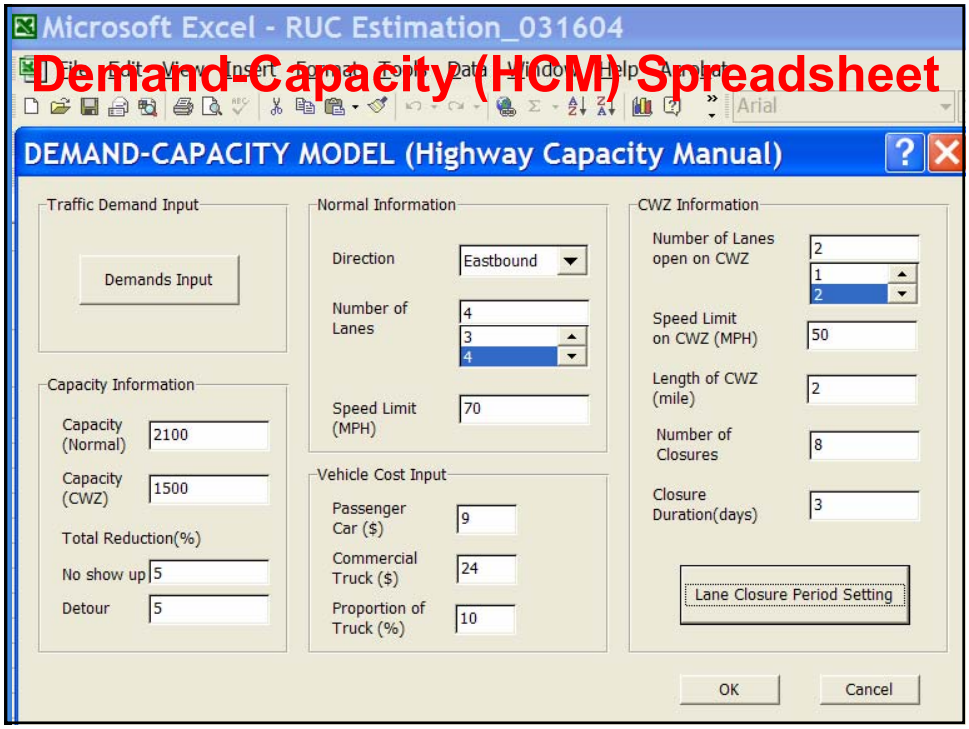


CA4PRS Input (4): Design & Traffic



CA4PRS Output Screens

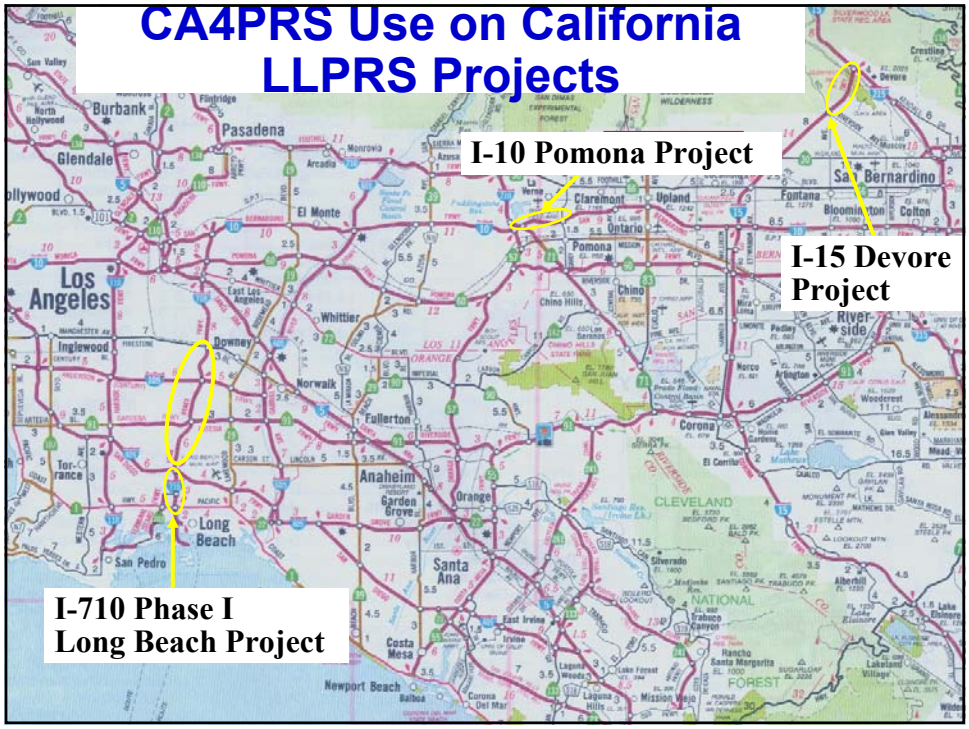




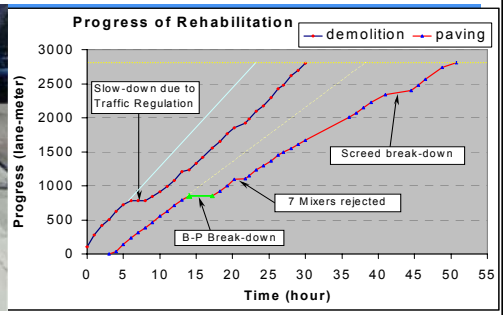
CA4PRS Pilot Projects

- I-10 Pomona (D7): FSHCC
- I-710 Long Beach (D7): AC
- I-15 Devore (D8):12-hour PCC

CA4PRS Use on California LLPRS Projects



I-10 Pomona Project CA4PRS Verification



55-hour Weekend Production

- Contractor's Plan = 3.5 lane-km
- CA4PRS Estimate = 2.9 lane-km (2.4-3.4)
- Actual Performance = 2.8 lane-km

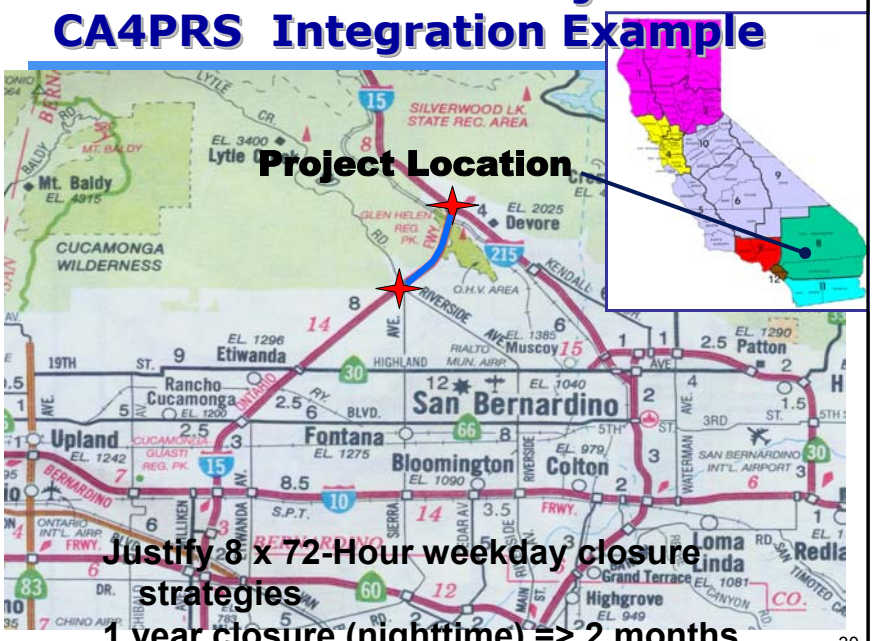
I-710 Long Beach project

CA4PRS Recommended to Revise the Contractor's Staging Plan

	CSOL	FDAC
Estimate	0.4 l-km	1.2 l-km
Plan	0.8 l-km	1.1 l-km
Actual	0.4 l-km	1.1 l-km

I-15 Devore Project

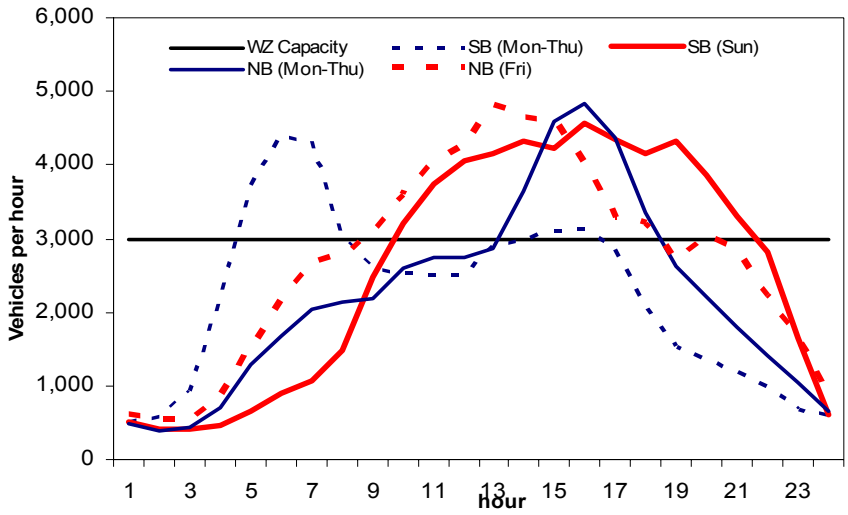
CA4PRS Integration Example



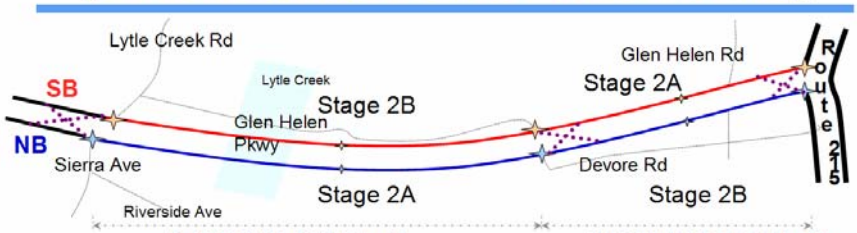
Justify 8 x 72-Hour weekday closure strategies

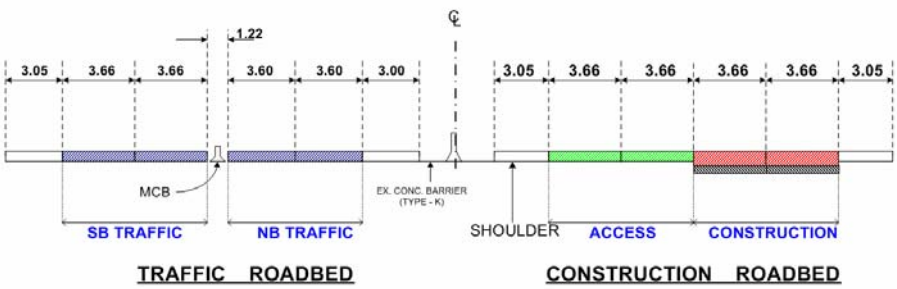
1 year closure (nighttime) => 2 months

I-15 Devore: Daily Traffic Patterns



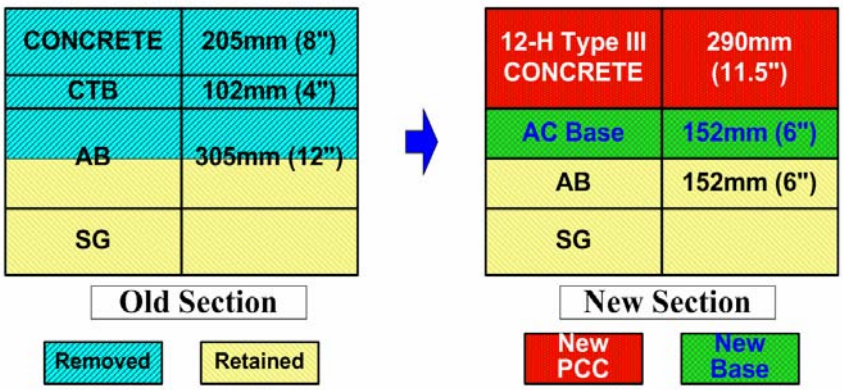
Stage Construction Scheme (Full Closure: Counter-flow Traffic)





I-15 Devore Concrete Pavement Cross-section Changes

- 200mm PCC with 100mm CTB =>
  300mm PCC with 150mm AC Base
- Early-Age Strength Type III PCC (400 psi (f) in 12-H)



I-15 Devore: Construction Scenarios Evaluated

- **Basic: Construction Windows**
  - 72-Hour Weekday Closures
  - 55-Hour Weekend Closures
  - 1 Roadbed Continuous Closures
  - 10-Hour Night-time Closures
- **Constructability Reviews**
  - Variation of 72-Hour Weekday Closures
  - Mix Design: 12-Hour Type III vs. FSHCC
  - Base Type: Lean-concrete vs. AC Base
  - Widened truck lane vs. Tied-shoulder

RETE 205m
TB 102m
AB 305m
SG

I-15 Devore: Schedule Comparison CA4PRS Analysis Results

	Construction Scenario	Total Closures	Total Closure Hours	%
(2)	72-Hour Weekday	8	512	100%
(3)	55-Hour Weekend	10	550	110%
(1)	1 Roadbed Continuous	2	400	78%
(4)	10-Hour Night-time	220	2,200	430%

I-15 Devore Selected the Most Economical Scenario: Schedule, Traffic Delay, Total Costs

Construction Scenario	Schedule Comparison		Cost Comparison ($M)			Max. Peak Delay (Min)
	Total Closures	Closure Hours	User Delay	Agency Cost	Total Cost	
72-Hour Weekday Continuous	8	512	5.6	12.6	18.2	75
55-Hour Weekend Continuous	10	550	14.2	15.1	29.3	195
1 Roadbed Continuous	2	400	6.9	9.9	16.8	195
10-Hour Night-time Closures	220	2,200	4.9	20.4	25.3	35

Lane Closure Review Committee Approved 72-Hour Weekday Closures (March 2003)

I-15 Devore Budget Reality Check
Downsize Rehab. Scope with CA4PRS

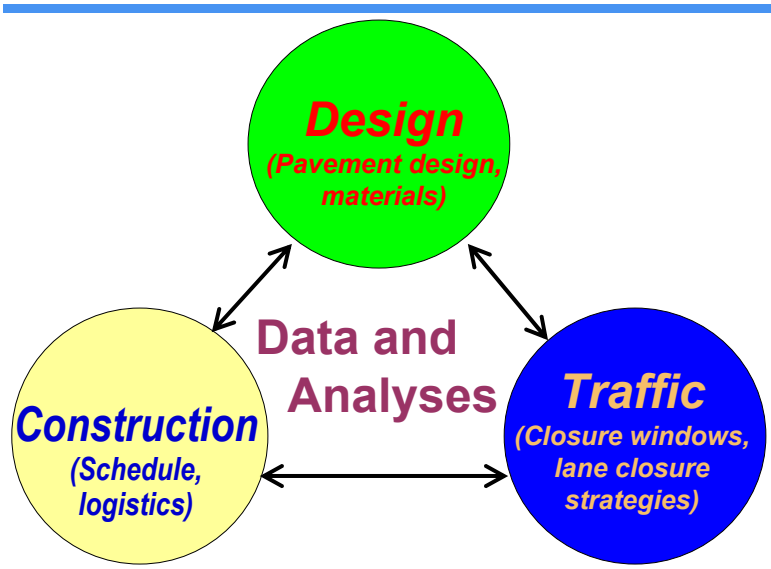
- **Result of the First Bids (2003 Fall)**
  - Estimate ($12M) vs. Lowest ($21M)
    - *Mainly Due to High Traffic Control Costs*
  - Construction schedule (2004 Spring => Fall)
- **Impact on Rehabilitation Scope**
  - Project Scope Reduction: Budget Constrained
  - Only Outer truck-lane Reconstruction
  - Inner truck-lane: Random Slab Replacement
- **Revised Scenario Analysis**
  - Selected Full-closure compared to Half-closure
  - CA4PRS Estimated 6 x 3- or 4-day Closures

CA4PRS Deployment Efforts

Candidate Projects for the CA4PRS Implementation

- Long-life Pavement Rehabilitation
- Accelerated Construction with Round-the-clock Operations
- High-profile Pavement Rehabilitation with Heavy Traffic in Urban Environment
- Public Outreach Needed Project
- Project Size: Minimum $X Millions
- Cycle: Planning => Design => Construction
- Lessons Learned Data : during construction

CA4PRS Facilitates Integration of District User-Group Teams



Who Uses CA4PRS?

- Training Workshops: 4-state Fund
  - Caltrans Materials Academy: 4-hour class (D8) - 2003
  - 4-DOT x 2 Workshops: 1-day class (D8/D7) - 2003
  - Training for In-state Trainers: 4-day (D3/HQ) – 2004
- 4-State CA4PRS Experiences
  - CA: I-10, I-710, and I-15
  - MN (I-35), TX (Pegasus), WA (I-5)
- American Concrete Pavement Association (ACPA) distributes CA4PRS
- NAPA is Considering to distribute CA4PRS

CA4PRS Outreach DRI and PPRC Efforts

- **In-house Outreach: DRI Website**
  - **Detail information available**
  - **Software downloadable**
- **Public Outreach**
  - **Brochure and Poster**
  - **TR News Articles**
  - **Reports and Journal papers**
  - **ACPA & NAPA: Conferences, Magazines**
- **Training for Caltrans**
  - **Some training performed**
  - **Need to identify Caltrans users and transfer use to Caltrans**

Recommended CA4PRS Training

- Recommend 2-day Hand-on Training Class
  - 10-15 Trainees per Class
  - Need Computer Lab Facility
  - Need Fund Supports
  - Technology Transfer Program
- Who Should be Recommend for Training
  - D3, D4, D6, D7, D8, D11, D12
  - Target: Design/Construction/Traffic Engineers
- Needs HQ Coordination
  - Present to District Division Chief Meetings
  - Introduction to District Level

CA4PRS Enhancement and Upgrade (PPRC and 4-State Supports)

- V1.0 Traffic Analyses handled separately
  - PRC Developed a HCM Spreadsheet
- V1.5-a: Userability & Interface Improvement
  - Develop the Manual
  - Improve Userability
- V1.5-b: Add more Rehabilitation Strategies
  - Mill & fill AC Rehabilitation
  - CRCP Rehabilitation
- V2.0: Traffic Analysis (Road User Cost)
  - Demand–Capacity Model (Highway Capacity Manual)
  - Economic analysis (RUC + Agency Cost)

Discussion

Needed HQ Support for CA4PRS Deployment

- Support for Training
  - Budget required
  - Introduction to Major Districts
- Implementation to District Level
- More Case Studies for Implementation
- Maintenance and Technical support
- Enhancement

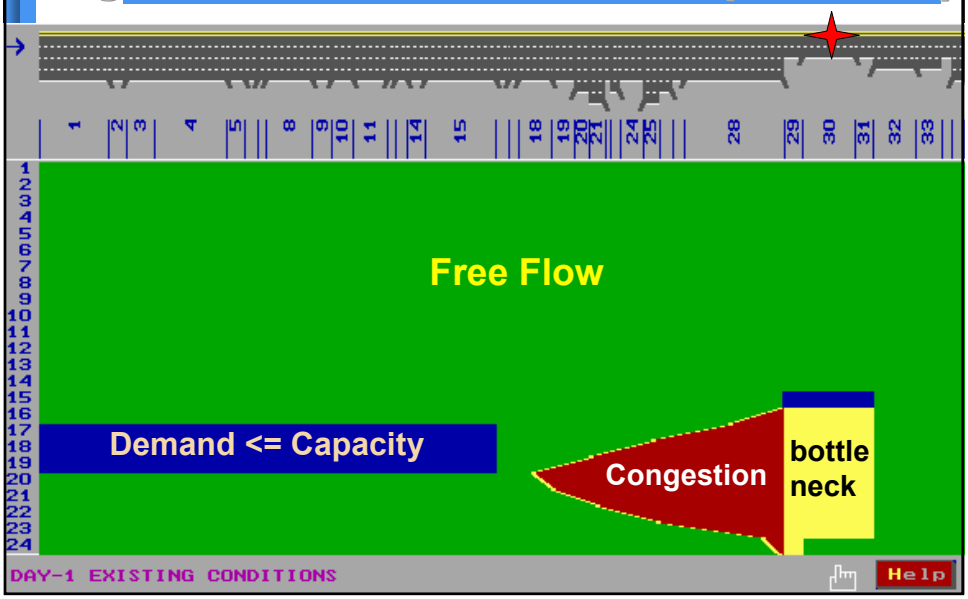
CA4PRS Additional Information

I-15 Devore: Traffic Analysis Models Integrated with CA4PRS

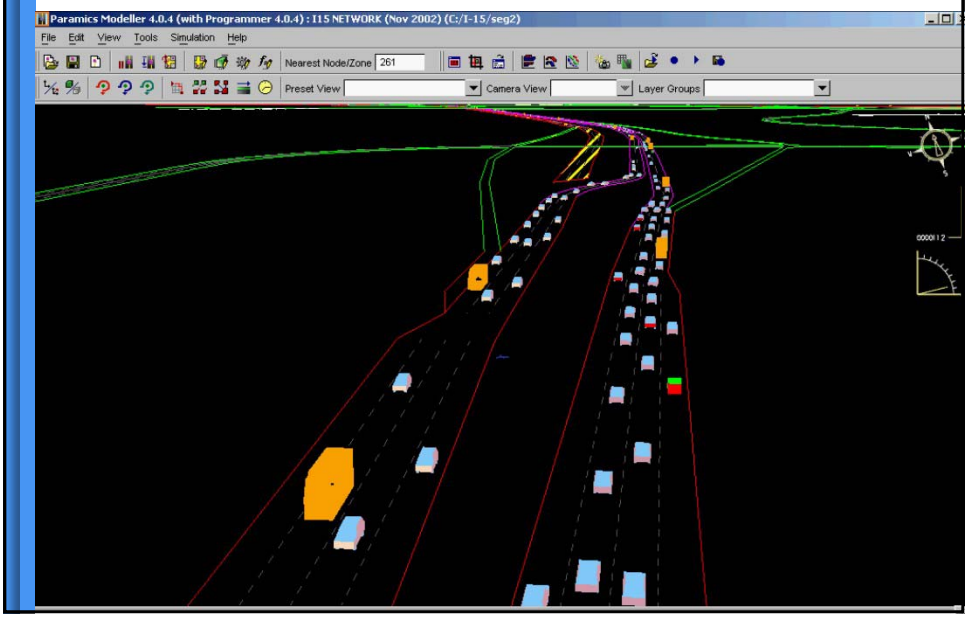
- **Step 1: Demand-Capacity Model (HCM)**
  - Road user cost: Compare all scenarios
  - Select the most economical scenario: Total cost
  - Sensitivity for TMP (Demand reduction, CWZ capacity)
- **Step 2: Macro Traffic Simulation (FREQ)**
  - Focus on the Selected Construction Scenario
  - Baseline for Incentives/disincentives and A+B contract
  - Develop lane closure charts
- **Step 3: Microscopic Simulation (PARAMICS)**
  - Blocking Freeway Connector: I-210 to I-15 NB
  - Truck restriction during peak hours through CWZ
  - Relocate the junction split location

FREQ Macro-simulation

Segment 1 Northbound Closure (NB traffic)



Paramics: Macroscopic Simulation Model



PRE-CONSTRUCTION

design

design integration

public outreach

CONSTRUCTION

POST-CONSTRUCTION